Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Amendment of Part 97 of the	)
Commissions Amateur Radio	)
Service Rules to Permit Greater	) RM-11708
Flexibility in Digital Data	)
Communications	)

To: The Chief, Wireless Telecommunication Bureau
Via: The ECFS

COMMENTS OF STEPHEN B. HAJDUCEK, N2CKH

The undersigned, **STEPHEN B. HAJDUCEK**, pursuant to Sections 1.41 and 1.405 of the Commission's rules (47 CFR Sections 1.41, 1.405) respectfully offers these comments **in support** of the above-captioned Petition for Rule Making.

COMMENTS:

1. **I am in agreement with and strongly recommend the adoption of RM-11708 with Erratum as amended by the ARRL** for the following reasons that are expanded upon in these comments.

A. Interoperability, especially for emergency operations communications, with Amateur services worldwide and government agencies served.

B. More efficient emergency communications modes.

C. Improved spectral efficiency below 29.7Mhz regarding data emissions.

D. Increased throughput and more Robust waveforms for all communications needs.

E. Advancing communications technology by developing and experimenting with advanced digital waveforms and technologies.

F. Permits the application of open specification U.S. and NATO Military standards based 3kHz HF channel waveforms in DSP software modem development.

G. Permits the use of more types of COTS available commercial and military HF hardware modems where many provide improved channel occupancy detection.

2. It is significant that the ARRL has petitioned to remove the symbol rate limits and implement a bandwidth limit for data emissions. As an ARRL member I am proud of the open process[1] and public comment[2][3] approach taken by the ARRL in gathering data to analyze the interests and desires of the entire World Amateur Radio community in arriving at their position.

3. There is no doubt that the U.S. Amateur Radio Service (ARS) is part of the nation's communications infrastructure, a review of "U.S. S.191 Amateur Radio Emergency Communications Enhancement Act of 2011"[4] makes that abundantly clear in:

2) Amateur Radio Service operators provide, on a volunteer basis, a valuable public service to their communities, their States, and to the Nation, especially in the area of national and international disaster communications.

Therefore I submit that the adoption of RM-11708 is critical in enabling the ARS to continue providing vital public service to both the Nation and the World where the requirement of interoperable data waveforms and other communications practices as used by those to whom the ARS provides service are significant factors in the ability of the ARS in providing communications support. However at present the ARS is prevented from fulfilling its role fully due to the existing rules, to especially include symbol rate limits.

4. I view RM-11708 as an opportunity being presented to the FCC to promote innovation and thus almost ensuring the unfolding of a communications revolution within the ARS as we move further into the 21st Century. Encouraging the highest and best use of spectrum and providing leadership in strengthening the defense of the nation's communications infrastructure

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[1] Document #28, 2013 Second Meeting, ARRL Board of Directors Report of the Ad Hoc Symbol Rate Rule Modernization Committee http://www.arrl.org/files/file/About%20ARRL/Committee%20Reports/2013/July/Doc_28.pdf

[2] The ARRL Letter, Vol 26, No 08 on February 23, 2007, ARRL Invites Comments on New HF Digital Protocol, http://www.arrl.org/arrlletter?issue=2007-02-23

[3] Results of HF Digital Protocol Survey, Paul L Rinaldo, W4RI, Chief Technology Officer, ARRL http://www.tapr.org/pdf/DCC2007-DigitalProtocolSurvey-W4RI.pdf

[4] U.S. S.191 Amateur Radio Emergency Communications Enhancement Act of 2011 http://nyc-arecs.org/s191.pdf

are expressed as core competencies[5] of the FCC, which the FCC can apply to the ARS via adoption of RM-11708.

5. The adoption of RM-11708, in providing access to high symbol rate waveforms, will represent a good first step forward below 29.7Mhz in the needed modernization of FCC Part 97 Rules in support of the ARS achieving improved spectral efficiency and interoperability which under current rules is largely unobtainable. The adoption of RM-11708 will allow access to the current "state of the art" in HF digital communications waveforms, a milestone event that will benefit both the ARS and the public served by the ARS in numerous ways. I shall comment in support of RM-11708 in stating my positions as well addressing some issues raised by others with my counter position and I shall provide technical reference to substanciate my comments herein.

6. The adoption of RM-11708 would be very timely with respect to the ever developing digital age where numerous target hosts and the development approaches can now economically be untaken by the Radio Amateur which range from the common PC Sound Device modem to embedded hosts. The most exciting targets are the ever more powerful developments taking place with inexpensive single board computers and dedicated DSP and FPGA development boards and their development tools which are all within the Radio Amateurs' budget. The more advanced Software Communications Architecture (SCA)[6] waveform development approach used in Software Defined Radio (SDR) development is the most common approach for commercial and military SDR based development, where the use of free development tools such as OSSIE[7] and others can be embraced by the Amateur Radio developer just as used by many commercial

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[5] Federal Communications Commission http://www.fcc.gov/what-we-do

[6] SCA is an open specification sponsored by the U.S. Department of Defense Joint Tactical Radio System (JTRS) program. It specifies architecture requirements such as software, hardware, and networking for open, programmable SDR systems with flexible, re-programmable communication capabilities. The SCA specifies a common framework to build-up, configure, connect and tear down distributed, embedded radio applications while maximizing waveform portability.

[7] OSSIE Open Source Software Defined Radio (SDR) development at Wireless@Virginia Tech http://ossie.wireless.vt.edu/trac/

developers. Mathworks toolsets where student versions[8] are available are another route that can be taken, the open specification Military standard waveforms for example are the subject of DSP engineering study and many have been modeled using the Communications System Toolbox[9].

7. PACTOR IV was referenced as an example commercial modem protocol in justification of RM-11708 by the ARRL. It also represents a real world waveform development example of MATLAB, which was used in the development process of 4G PACTOR IV[10]. PACTOR IV provides 10 proprietary waveforms for those interested in its decoding[11], where level 1 is a 100 baud Robust DPSK4B 2-tone Chirp waveform with top speed of 46.9bps[12]. The speed levels 2-10 for a top coded data rate of 5512bps[12] and 3-path RAKE receiver for levels 2-4 were designed by renowned STANAG modem engineer Dr. Eberhard Gamm[13] over a 3 year period. An 1800 baud symbol rate (@2.4kHz BW) was chosen for the single-carrier waveform modes with an adaptive decision feedback equalizer (DFE) receiver. The bandwidth is variable over the 10 waveform modes but always at less than 2.4kHz by design to support marketing their proprietary modem to their Amateur Radio and non-Amateur user bases to achieve maximum performance with the typical SSB filter characteristics common in their user base. MATLAB was used for design implementation and algorithm evaluation, where the resulting algorithms were then ported to C ++ and then exercised on a PC-based demonstrator for on-air testing. Then a final code port was required from the PC-based demonstrator to the target real-time StarCore DSP processor for final testing and fielding. PACTOR IV using this approach entered the market place in 2011, an overall 6 year process, representing 20 man years of team development effort. With adoption of RM-11708 what may come about in the way of ARS developments within a 6 year

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[8] Mathworks Student Version http://www.mathworks.com/programs/nrd/buy-matlab-student-version.html

[9] http://www.mathworks.com/help/comm/examples/defense-communications-us-mil-std-188-110b-baseband-end-to-end-link.html

[10] PACTOR 4 http://www.p4dragon.com/en/PACTOR-4.html and http://www.sea-tech.com/SCS-p4dragon-dr-7400.pdf

[11] MEDAV VD Pactor Demod http://www.medav.de/fileadmin/redaktion/documents/English/vd_PACTOR_demodulator.pdf

[12] Data rate throughput without the use data compression

[13] http://translate.google.com/translate?hl=en&sl=de&u=http://www.ibega.de/&prev=/search%3Fq%3D%2522matrix%2Binversion%2Bequalizer%2522%2BSTANAG%26hl%3Den%26biw%3D1024%26bih%3D660%26prmd%3Dimvns&sa=X&ei=YeJDUJ-HD4Lk9ATG3YHQCg&ved=0CFAQ7gEwBQ

period without the current symbol rate limits in place is unknown. However we may never know what the ARS can achieve in these disciplines unless RM-11708 is adopted.

8. I possess over 50 years of VLF/LF/MF/HF+ radio experience which began with Short Wave Listening (SWL) that fascinated and motivated me at a young age to learn more about Radio Science. That lead to becoming a Radio Amateur which inspired me even more and also had a large impact in many ways on my professional career[14] prior to retirement. As an Extra Class, licensed 34 years and having diverse ARS interests and experience and as a software modem developer of free Amateur Radio digital mode tools, I very much appreciate the potential benefits and positive impact the adoption of RM-11708 shall have on the ARS.

9. The current FCC symbol rate limits are an impediment to progress as they needlessly restrict and complicate the technical approaches that can be undertaken in either single-carrier or parallel-carrier high speed waveform experimentation and development. This is especially true with respect MIL-STD and STANAG single-carrier (serial tone) PSK FEC coded waveforms, which are my body of study. My development focus of interest being full adherence to the military standards for hardware modem interoperability. I shall draw upon my knowledge of these open Military standards in many of my comments in support of RM-11708.

10. The adoption of RM-11708 will provide the capability to make use of high speed open specification[15] U.S. Military Standard (MIL-STD), open specification Standard NATO (STANAG) and proprietary Commercial waveforms that operate at symbol rates in excess of the current limits to provide interoperable communications with Humanitarian, Local, State and U.S. Government and Military stations which is in keeping with the intent of FCC *§97.1(a)*

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[14] www.n2ckh.com/RESUME/STEPHEN_B_HAJDUCEK_PUBLIC_RESUME.pdf

[15] Interoperability is ensured in all U.S. and NATO Military radio systems through the use of open specification military standards and provide Defense Industry guidance in the development of military equipments.

(a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

11. The adoption of RM-11708 will provide relief from the current symbol rate limitations and will directly motivate experimentation leading to new developments and thus potentially contribute to the advancement of the radio art which is in keeping with the intent of FCC *§97.1(b)*

(b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

12. The application of open specification MIL-STD or STANAG waveforms within the ARS are in keeping with the intent of FCC *§97.309(4)*

(4) An amateur station transmitting a RTTY or data emission using a digital code specified in this paragraph may use any technique whose technical characteristics have been documented publicly, such as CLOVER, G-TOR, or PacTOR, for the purpose of facilitating communications.

However the current symbol rate limits restrict their application to the detriment of the ARS. This is also true of what have become commonly used ARS developed non-proprietary waveforms in wide use outside the U.S., for example PSK-500, PSK-500R, BPSK-500, QPSK-500 which all exceed 300 baud and all have ITU designation 1000HG1B.

13. As a software modem developer, under the current rules there is no motivation for me to develop software modems for ARS use in support of the NATO BRASS[16] waveform, STANAG 4529[17] (S4529) which is the only 1200 baud symbol rate (1.24kHz BW) Military waveform as its use would be limited to 60 meters and 10 meters. S4529 occupies about 1.0kHz less bandwidth than most all other FCC legal waveforms that can provide 1200bps coded throughput with strong Forward Error Correction (FEC) which it provides along with deep

[16] Broadcast & Ship-Shore System (BRASS) is a NATO project that allows all NATO maritime communication centres to facilitate automatic control and management of the communication assets.

[17] NATO STANAG 4529, "Characteristics For Single Tone Modulators/ Demodulators For Maritime HF Radio Links With 1240 Hz Bandwidths", Edition 1, 20 January 1998

interleaving and constant resynchronization superior to familiar modes like MT-63[18] and also supports late entry after the data emission has begun, which those who have used MT-63[19] are familiar with.

14. As an ALE[20] operator the symbol rate limits restrict me to using 8ry AFSK on all bands as all other MIL-STD and STANAG serial tone data modem waveforms are 2400 baud, requiring 2.8kHz. This includes the optional AQC-ALE[21] burst mode and 3G ALE[22] which is all burst waveforms based. This precludes taking advantage of 3G ALE except for limited single band 60 meter use where symbol rate is not specified. The ARS would benefit from 3G ALE synchronous scanning, faster linking, robust PSK burst mode signaling, 10db SNR improvement over AFSK 2G ALE, Carrier sense multiple access with collision avoidance (CSMA/CA) channel access procedure, improved spectral efficiency, channel occupancy detection down to –9db/SNR or better for the Robust Link Set Up BW0 waveform and as 3G ALE Soundings are not required the channel occupancy is dramatically reduced.

15. In RM-11708 the ARRL proposes to delete all references to symbol rate from Section 97.307(f) of the Commission's rules; to create a conforming amendment to Section 97.305(c) of the rules; and to establish a bandwidth limit of 2.8kHz. At present, aside from the requirements set forth in FCC §97.221(c,2) at 500hz and FCC §97.303(h) at 2.8kHz bandwidth, there currently exists no other by bandwidth restrictions for data emissions below 29.7Mhz. However RM-11708 technically represents a reduction in permitted Data emission bandwidth per transmitter carrier frequency to 2.8kHz as being requested. Keeping those facts in mind, take into consideration that

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[18] MT-63 ARRL http://www.arrl.org/mt-63

[19] MT-63 Presentation for Navy-Marine Corps MARS http://www.navymars.org/central/reg4/al/MT63.pdf

[20] Automatic Link Establishment http://www.arrl.org/files/file/Technology/tis/info/pdf/9502068.pdf

[21] MIL-STD-188-141B, Interoperability and Performance Standards for Medium and High Frequency Radio Systems, Notice 1, 31 August 2001; A.5.8.1.6.2 PSK tone sequence generation (NT)

[22] STANAG 4538 (EDITION 1) - Technical Standards For An Automatic Radio Control System (ARCS) For HF Communication Links, 24 February 2009, Annex C, 13. Arcs Waveforms

STANAG 4539[23] (S4539) which in RM-11708 section III (10) the ARRL obviously referenced as a justification with the statement

"*There are emissions which are utilized by the United States Government, such as STANAG, which has a 2400 baud symbol rate and can fit within a bandwidth of 2.8 kHz*"

combined with footnote

"[18] *STANAG has a data speed of between 2400 and 9600 bits per second*".

As S4539 requires a 2.8kHz bandwidth to provide full performance and taking into consideration 60 meters where a bandwidth of 2.8kHz is specified as a precedence, **I recommend that no less than 2.8kHz as requested in RM-11708 be considered by the FCC**. However my recommendation is not meant to suggest the FCC preclude consideration of the merits to a wider data emission bandwidth limit. It is worth noting however that with proper radio IF filters as to variations in attenuation and group delay characteristics[24], no greater bandwidth is required for any existing 2400 baud fixed symbol rate coded or uncoded military waveform designed for a standard 3kHz SSB HF channel. For example the new MIL-STD-188-110C[25] 64-QAM 12,000bps and 256-QAM 16,000bps waveforms utilize more advanced modulation, achieving higher data rates, yet require only 2.8kHz bandwidth. These two waveforms represent the current "state of the art" in Military serial tone waveforms for a single 3kHz SSB HF channel.

16. The adoption of RM-11708 will the permit use of open specification U.S. and NATO Military 3kHz HF channel waveform standards. The MIL-STD-188-110A/B/C series of standards detail both legacy waveforms FSK, 16-tone Differential Phase-Shift Keyed (DPSK) and 39-tone Quadrature Differential Phase-Shift Keying (QDPSK) both Orthogonal Frequency-Division Multiplexing (OFDM) waveforms. Also detailed are well known 8PSK, BPSK, QPSK, QAM and

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[23] STANAG 4539 C3 (EDITION 1), Technical Standards For Non-Hopping HF Communications Waveforms, 8 June 2006

[24] Variations in attenuation at most are +/-2db and a Group Delay time over 80% of passband must not be more than .5ms

[25] MIL-STD-188-110C, "Interoperability And Performance Standards For Data Modems", 23 Sept 2011

WALSH modulated Serial Tone waveforms. These and other open specification Military standards have obviously influenced many aspects of low symbol rate Amateur Radio waveform developments that have taken place over the last 25 years as well as many Commercial waveform developments where HF Data Link (HFDL)[26] is the best documented influenced serial tone modem example. The Rockwell HF proprietary narrow band Airborne and Maritime serial tone waveforms in their MDM-Q960x[27] series modems are additional well known examples which target commercial radios with narrower and poorer response SSB filters. The MDM-Q960x modems are also excellent examples of military waveforms running on a dedicated Linux computer as the modem host.

17. Many of the open military standard serial tone waveforms have been in existence for over 20 years now. The serial tone modems improved performance in multi-path fading channels replaced OFDM[28] in common Military use just as OFDM had replaced various Military DPSK and Voice Frequency Carrier Telegraph (VFCT) systems a.k.a. Diversity RTTY[29] which surpass the performance of two-tone RTTY in common ARS use still today. Though largely ignored in the U.S. for Amateur Radio application due to their symbol rates, these the legacy serial tone waveforms are all still heavily used by Government, Military and other users domestically and world wide due to their performance. I can't begin to stress how much benefit these open specification standards represent to the future of the ARS in my opinion. Regardless of being implemented in software as specified for interoperability with hardware systems as in my focus or modified for use or just studied and experimented with as inspiration for new innovation. The

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[26] AMCP/4-WP/70 Appendix to the Report on Agenda Item 6, 6A-1 Report From The Ad Hoc Working Group On HF Data Link section 3.2.2.1.5 (http://legacy.icao.int/anb/panels/acp/meetings/amcp4/item-6a.pdf)

[27] htps://www.rockwellcollins.com/~/media/Files/Unsecure/Products/Product%20Brochures/Communcation%20and%20Networks/Communication%20Radios/MDMQ9604%20data%20sheet.aspx

[28] http://www.hfindustry.com/meetings_presentations/presentation_materials/2011_jan_hfia/presentations/03_JOHNSON%20_StandardsRevisionStatus.pdf page 7, removal of MS110A App. A, 16 tone OFDM, retention App. B 39 tone OFDM for MIL-STD-188-110C

[29] MD-1142/UGC Military RTTY modems, commercially BR6029C, 7 channel diversity plus 1 pilot channel are still popular with many sophisticated ARS users, but unfortunately to the detriment of the ARS it never became a commonly used mode of RTTY.

ability to utilize these waveforms in existing commercial and military surplus hardware alone would represent a significant added capability and added value to the ARS.

18. "AS IS" the adoption of RM-11708 would not allow for use of the must have 75bps STANAG 4415[30] (S4415) waveform which provides the most robust weak signal and poor channel performance within only 2.8kHz of any Military waveforms referenced herein. It was designed to provide communications under extreme HF channel conditions of negative signal to noise ratios, large Doppler spreads and large multipath delay spreads and proven in applications of worst case real world environments where typical Doppler frequency range equal +/- 40Hz in testing within the DAMSON[31] environment at high latitudes[32]. S4415 performs in interference environments where the interferer may be as much as 40 dB stronger than the signal of interest[33]. It must be noted that S4415 and the MIL-STD-188-110A/B/C 75bps data rate waveform are the same and thus are interoperable, however S4415 modems are required on both ends for full robust performance benefits. It must also be noted that the waveforms use a Walsh coded **in-band** Direct Sequence Spread Spectrum (DSSS) modulation scheme for the inherent ability of DSSS to deal with interference and ionospheric multipath. The low data rate signal is modulated with a high rate pseudorandom sequence with a small amount of noise added to the modulated signal. Although both waveforms are the same as to emission, the receiver requirements are not. The MIL-STD modem receiver minimum performance requirements for 75bps are defined as 2db/SNR @ 3khz AWGN with 5ms multipath and 5hz fading. However the S4415 modem receiver performance requirements are much stricter and thus make for much more Robust performance as delivered. The S4415 performance requirements are Bit Error Rate (BER) $<10^{-3}$, -

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30 NATO STANAG 4415, "Characteristics Of A Robust, Non-Hopping, Serial-Tone Modulator/Demodulator For Severely Degraded HF Radio Links", Edition 1, 21 June 1999

31 DAMSON (Doppler And Multipath SOunding Network) is an oblique channel sounding system which has been developed by the UK Defence Research Agency (DRA) to measure a number of real-time channel parameters using low power pulse compression waveform transmissions. http://adsabs.harvard.edu/abs/1994mmpp.agarR....D

32 NATO $MP-026-35 http://ftp.rta.nato.int/public/PubFullText/RTO/MP/RTO-MP-026/$MP-026-35.PDF

33 Improving the LPI and self-interference characteristics of the STANAG 4415 very robust HF waveform. M. B. Jorgenson, R. W. Johnson, P. F. Jones, W. M. Bova, K. W. Moreland ISBN: 0-7803-7625-0

9db/SNR @ 3Khz AWGN single path, non-fading channel. For BER $<10^{-4}$, dual path and multipath = 10.0ms where all the requirements are detailed in table 1 of the attached Appendix I as to fading and SNR @ 3Khz AWGN channel parameters. In comparison to the MS110A receiver performance requirements 2hz fading and only 5ms of multipath, S4415 delivers at – 1.0db/SNR for 2hz fading and 10ms multipath and where S4415 supports up to 30hz fading at – 1.0db/SNR. Although not specified in the details of RM-11708, however in keeping with the scope and intent of RM-11708 as the vehicle of opportunity, I ask that the FCC consider the merits of the 75bps DSSS waveform as used by S4415 and MS110A and benefits provided to the ARS from their use by incorporating rule changes that would permit in-band DSSS but not to exceed any resulting emission bandwidth specified in conjunction with an approval ruling on RM-11708. However, I am **NOT** attaching my position on DSSS as a condition for adopting RM-11708 by the Commission.

19. The adoption of RM-11708, in my opinion, will significantly motivate Amateur Radio experimentation within and beyond the U.S. I expect to see a surge of high symbol rate waveform and resulting data link protocol development which will positively impact not only Data but also Image, Digital Voice, HF e-mail and Propagation tools and possibly contribute to advances in the "state of the art". We are talking beneficial change on the order of magnitude that the ARS has not seen since transitioning from Amplitude Modulation to Single Sideband in my opinion, but without any mode lost or and forced equipment changes as in the monumental advance from Spark-Gap to Continuous Wave (CW). The ARS is all but certain to benefit from modern high symbol rate digital waveform coding and redundancy techniques such as can be provided with Military standard waveforms and data link protocols. For example, from use of Military standards we can expect benefits in the form of 3G ALE, automated client/server message forwarding systems, peer-to-peer communications, multicast, ECOM and more, to include but not limited to improved spectral efficiency from increased throughput from higher

data rates, more robust waveform performance as to channel conditions, more efficient FEC and ARQ, less channel occupancy time per message and better channel occupancy detection.

20. The general purpose computer coupled with a PC Sound Device as the modem hardware has been just about powerful enough to support Digital Signal Processing (DSP) to implement MIL-STD or STANAG PSK serial tone waveforms for over 10 years at this point. For example, I am the developer of MARS-ALE and MIL-STD Data Modem Terminal[34] (MS-DMT) software tools used by the MARS[35] and SHARES[36] programs. Both tools are largely based on PC-ALE which I assumed application lifecycle management and continue to develop. PC-ALE was originally developed by Charles Brain, G4GUO (who is also known for his digital voice efforts[37] and DATV[38] developments) as a proof of concept ALE demonstrator under MS-Windows. G4GUO was motivated and able to design, develop and integrate a 2400 baud symbol rate MIL-STD-188-110A[39] (MS110A) serial tone data modem into PC-ALE and test it on-the-air under U.K. Amateur rules where there are no bandwidth or modulation restrictions. In the U.K. an emission must fit within the given Amateur band in which it is used, theoretically from band edge to band edge. In 2009 G4GUO created "CadetALE", based on PC-ALE, but for "UK Cadet Corps."[40] to support interoperability with their Harris Falcon radios[41] and the radios used by those they support. CadetALE has added enhanced Channel Occupancy Detection; Link

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34 http://g4guo.blogspot.com/search?q=MIL-STD+188-110A+

35 The Military Auxiliary Radio System (MARS) is a United States Department of Defense sponsored program under DoD Directive (DoDD) 4650.2 (http://www.dtic.mil/whs/directives/corres/pdf/465002p.pdf), established as a separately managed and operated program by the United States Army, Navy, and Air Force. MARS is a civilian auxiliary consisting primarily of licensed amateur radio operators interested in assisting the military with communications on a local, national, and international basis as an adjunct to normal communications. MARS programs also include active duty, reserve, National Guard units, Federal and State Government stations.

36 SHAred RESources (SHARES) High Frequency (HF) Radio Program is administered by the U.S. Department of Homeland Security's Office of Emergency Communications (OEC), it provides an additional means for users with a national security and emergency preparedness mission to communicate when landline and cellular communications are unavailable. SHARES members (http://www.dhs.gov/sites/default/files/publications/SHARES%20Resource%20Contributors.pdf) use existing HF radio resources to coordinate and transmit messages needed to perform critical functions, including those areas related to leadership, safety, maintenance of law and order, finance, and public health.

37 http://www.arrl.org/files/file/Technology/tis/info/pdf/0056x003.pdf

38 2011 ARRL TAPRDigital Comm Conference http://www.tapr.org/pdf/DCC2011-DATVexpress-G4GUO-W6HHC.pdf

39 MIL-STD-188-110A, "Interoperability Performance Standards For Data Modems", 30 September 1991

40 U.K. Cadet Corps http://en.wikipedia.org/wiki/Sea_Cadet_Corps_%28United_Kingdom%29

41 UK Cadet Corp Harris Donation http://harris.com/view_pressrelease.asp?act=lookup&pr_id=1890

Protection (LP)[42] level 1 and 2; GPS, Internet and Radio-to-Radio Time Servers in support of LP levels 1 and 2; enhanced FS-1052 Appendix B. Data Link Protocol[43] support with ARQ Circuit Mode added to existing ARQ Normal and Fixed modes and an added authentication capable SMTP/POP3 server for direct HF/Internet e-mail support.

21. PC-ALE development as to the serial tone modem and on-the-air testing via Amateur Radio took place over 10 years ago now, where UK and other Amateurs outside the U.S. have been able to make use of the serial tone modem while U.S. Amateurs have been excluded due to FCC symbol rate limit rules. The interest within the U.S. regarding such development of Military standards for ARS use has long existed as a technical challenge, N4HY, a contemporary of G4GUO published research[44] on the subject matter nearly 15 years ago running on Linux, however that research was never culminated in release of software tool. In addition, aside from high speed HF e-mail and requirements for ARQ, the potential benefits must be noted regarding waveforms providing a pseudo-random binary (PN) sequence as used in STANAG 4285[45] (S4285) and S4529 coupled with the strong FEC and constant resynchronization in those waveform standards. Such use can lead to very much improved waveforms and software tools to enhance practices to include but not limited to peer-to-peer, multicast, RATT contesting, selective calling and propagation beacons where there is no need to adhere to the full Military standard requirements for interoperability. This has been demonstrated by Con, ZL2AFP in his excellent PSK Sounder[46] application which provides an alternate baud rate selection still in excess of 300 baud. Also worthy of mention, there exists for many years now RFSM-8000[47] by the RFSM-IDE Group, a client/server mailbox that features an S4539 class modem. It is very popular outside the

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[42] High Frequency Radio Automatic Link Establishment (ALE) Application Handbook. September 1998, Page 223,Annex 5, Linking Protection For Hf Ale Radio Networks

[43] FS-1052 Appendix B www.n2ckh.com/MARS_ALE_FORUM/FED-STD-1052.pdf

[44] A software Implementation for Federal Standard 1052 (Mil. Std. 188-110A HF Modems) by Robert McGwier N4HY, 1999, ISBN: 0872597679. http://www.tapr.org/pub_dcc18.html and http://test.tapr.org/mp3/dcc/dcc1999/dcc99.8a.n4hy.mp3

[45] NATO STANAG 4285, "Characteristics Of 1200/2400/3600 Bits Per Second Single Tone Modulators Demodulators For HF Radio Links", Brussels, Edition 1, 17 February 1989

[46] ZL2AFP PSK Sounder http://www.qsl.net/zl1bpu/SOFT/PSKSounder.htm

[47] http://www.marsregionone.org/Temp/rfsm-8000.pdf

U.S., especially in Europe, however aside from its symbol rate, its data link protocol is not published, as such it would never be FCC legal.

22. As a responsible Radio Amateur, past ARRL Official Observer (OO) and a software developer experienced with the application of Listen Before Transmit (LBT) technology, I truly appreciate the effort and challenge in developing improved LBT technology in support of use within the ARS. The self policing and self regulating aspects of the ARS such as volunteering as an OO and supporting Band Plans[48] and being a considerate operator were ingrained upon me by my mentors, as were knowing and following the FCC rules and regulations. I envision the application of Listen Before Transmit detectors transforming digital mode operations in the ARS.

23. There is some opposition to RM-11708 due to perceived issues of co-channel interference that may come about from its adoption. This opposition seems to be squarely focused on emissions from Automatically Controlled Digital Station. Although permitted under the present rules, when it comes to choosing a frequency to operate I truly believe that avoidance of the Automatically Controlled Digital Station sub bands by those that are not there to access a Message Forwarding System is the logical, proper and simple action for a considerate operator[49] to take in mitigating the potential of shared co-channel interference. However no band plans recognize and recommend this logic. It makes no sense to CQ in search of an arm chair QSO where active message forwarding systems exist with possible hidden transmitter or obvious activity taking place. It makes about as much sense as trying to have a leisurely arm chair QSO when a DX contest is taking place. However, regardless of logic, both practices are undertaken by choice as permitted under current FCC rules. The licensee of the manually controlled station has chosen to operate co-channel inside the Automatically Controlled Digital sub bands and thus subject themselves to the possibility of unintentional interference. It is my opinion that **NO**

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48 ARRL Band Plan http://www.arrl.org/band-plan
49 ARRL Considerate Operator Guide http://www.arrl.org/files/file/conop.pdf

consideration by the FCC should be given to any arguments against the adoption of RM-11708 on the grounds of perceived issues pertaining to the potential of co-channel interference.

24. There is some opposition to RM-11708 unless it is amended to mandate Channel Occupancy Detection. I strongly advocate the use of Channel Occupancy Detection in practical application as applied to the ARS. However I believe the current “state of the art” in ARS Commercial Channel Occupancy Detection technology should be carefully reviewed by the FCC as performance requirements and test procedures will require development. The criteria to be developed must be within reach of the ARS ability to adhere to requirements prior to an NPRM. This process will be lengthy and such an undertaking should not impact the timeline to adoption of RM-11708. It is my opinion that **NO** consideration should be given by the FCC to any arguments against the adoption of RM-11708 on the grounds of a requirement for Channel Occupancy Detection on the part of Automatically Controlled Digital Stations.

25. The issue of co-channel interference is attributed more to the human factor than anything else in my opinion. This is exemplified by issues experienced at 30 meters in ITU Region 1 where Message Forwarding Systems are not contained within a sub band and where self regulating band plans are not working to mitigate interference as detailed in “IARU Region 1 Committee C4 (HF Matters) Interim Meeting 20-21 April 2013”[50] report where it states in item “*2) Or is this now a lost case, so that we must modify the IARU Region 1 bandplan to allow for both manual and automatic digital transmissions at different frequency segments?*”
where separation of the two types of operations by governing authority is the obvious solution to interference mitigation.

[50] http://uska.ch/fileadmin/download/iaru/interim_meetings/vienna2013/VIE13-C4-04_NRRL.pdf

26. I am not opposed to a separate rulemaking process to mitigate the potential of shared co-channel interference between stations by mandating the use of Channel Occupancy Detection by all licensees involved in "Message Forwarding System" activities defined by *§97.219* and by "Automatically Controlled Digital Stations" as defined by *§97.221* and by <u>all other station licensees</u> participating in any activity involving data emission while operating within the sub bands defined by FCC *§97.221(b)*

(b) A station may be automatically controlled while transmitting a RTTY or data emission on the 6 m or shorter wavelength bands, and on the 28.120–28.189 MHz, 24.925–24.930 MHz, 21.090–21.100 MHz, 18.105–18.110 MHz, 14.0950–14.0995 MHz, 14.1005–14.112MHz, 10.140–10.150 MHz, 7.100–7.105 MHz, or 3.585–3.600 MHz segments.

should the FCC see the merit. A logical solution to mitigate co-channel interference is to remove the human factor and mandate Channel Occupancy Detection for all licensees operating within the automatic sub bands regardless of automatic or manual control being used. There are software tools are already in use within the ARS for peer-2-peer communications for various data emission types that support Channel Occupancy detection, examples of which that I have experience using are PC-ALE for ALE and AQC-ALE, RMS Express for WINMOR, V4 Chat for WINMOR V4 Protocol[51]. There are likely already others and more will follow, especially if given cause.

27. I am not opposed to a separate rulemaking process to mitigate the potential of shared co-channel interference between stations involved in "Message Forwarding System" activities as defined in *§97.219* and station licensees involved in other activities as currently as permitted when operating on the frequencies set forth by FCC *§97.221(b)*

(b) A station may be automatically controlled while transmitting a RTTY or data emission on the 6 m or shorter wavelength bands, and on the 28.120–28.189 MHz, 24.925–24.930 MHz, 21.090–21.100 MHz, 18.105–18.110 MHz, 14.0950–14.0995 MHz, 14.1005–14.112MHz, 10.140–10.150 MHz, 7.100–7.105 MHz, or 3.585–3.600 MHz segments.

[51]New V4 Protocol for Fast Keyboard Texting Over HF http://www.winlink.org/node/501

whereby the frequencies now allocated in *§97.221* become **exclusive** to Automatically Controlled Digital Stations as defined by *§97.221* and stations involved in “Message Forwarding System” activities as defined in *§97.21* should the FCC see the merit. If the potential of co-channel interference is limited to only those stations taking part in Message Forwarding System access and any other stations under automatic control, where all such stations are using modern Channel Occupancy Detection then a high level interference mitigation shall result as the human factor does not enter into the equation.

28. The existing Channel Occupancy Detection currently in use within the ARS that I have experience with works rather well and is being improved upon by ARS and commercial developers all the time[52]. Channel Occupancy Detection does not make a judgment call such as “I can barely hear that signal and its so weak that my transmissions won’t effect them either”. In addition the Channel Occupancy Detection detects weak signals into the noise that the human ear can not detect. There are many users of the WINMOR modem that rave about its performance. PC-ALE, which was likely the first tool to provide Channel Occupancy Detection as used by the ARS has incorporated Listen Before Transmit (LBT) technology from the beginning, as has MARS-ALE which is licensed by HFlink[53] as its ALE server software. The Winlink system incorporates the capability in its server and client tools and V4 Chat application. When WL2K TRIMODE using WINMOR is used behind MARS-ALE in HFlink for HF e-mail there exists redundant LBT verses the remote client just using BBSlink[54] via an ALE protocol. The redundant LBT results from MARS-ALE being used in establishing the ALE link and then with the follow on WINMOR link and that modems LBT detector use prior to the link. Redundancy exists with the remote PC-ALE or ALE radio client stations as well in making the linking calls.

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52 Rick Muething, KN6KB, WINMOR developer stated on Date: Mon, 5 Aug 2013 17:49:08 –0400 Subject: Re: [Winlink_Programs_Group] Busy Channel Detection in WL2K Programs Reply-To: Winlink_Programs_Group@yahoogroups.com “Recent updates to the busy detection algorithms in the new SCS Dragon TNCs are also good examples of how this technology is improving and becoming more universally available.”

53 HFLINK is the international resource for Amateur Radio HF-ALE Communications http://hflink.com/automaticlinkestablishment/

54 BBSlink provides MARS-ALE a configurable SMTP/POP3 or WL2K interface in support of AMD, DBM ARQ or DTM ARQ for HF e-mail were AMD use is similar to cell phone SMS messaging. http://hflink.net/bbslink/

29. The MARS-ALE and PC-ALE 1st Generation LBT approach worked fairly well but did not fully meet MIL-STD requirements in detecting all signal types required adequately and it would false detect on various types of received noise. In collaboration with G4GUO, I have recently implemented a second generation (2G) LBT detector in the developing baseline for MARS-ALE v3.00 to meet MIL-STD-188-141C paragraph 4.5(f) as to monitoring the entire channel and paragraph A.4.2.2 and TABLE A-I thereof as to occupancy detection probability requirements. The design undertaken does not make use of blind demodulation or any feature based identification[55], as was done in part to a minor extent previously and on my part was once considered to best approach to take. As such the new 2G LBT is applicable to all emissions and not just those encountered in Military or other specific targeted emission scenarios, making it better suited for application to Amateur Radio and dealing with whatever emission comes along. This 2G LBT technology will be ported to the developing version of PC-ALE v1.08 as well. We shall release the complete source code of the 2G LBT Class project, probably under a GNU GPL license, some time in 2014. The 2G LBT C++ Class exists as an MS Visual Studio project, compiled with multi-threading enabled to create an Object Library File (.lib) targeting use in an MS Windows 32 bit application, which shall also be provided.

30. The initial testing of the MARS-ALE 2G LBT[56] utilized one NSGdatacomm M1400A modem as a data source and three Rockwell MDM-3001 modems, one in HF Channel Simulator mode, one as a modem source and one in decoding of certain waveforms it supported. It was determined in testing that the new 2G LBT does not return a detection on AWGN and yet it exceeds all specified detection requirements. The previous LBT would false on noise. It was determined that the 2G LBT detects the various serial tone waveforms specified well below

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[55] Feature Based Automatic Classification of Single And multitone Signals http://faculty.washington.edu/paymana/papers/iasted09.pdf

[56] Preliminary Test Results of MARS-ALE Second Generation Listen Before Transmit Detector by N2CKH December 2013 www.n2ckh.com/MARS_ALE_FORUM/MARS-ALE_2G_Listen_Before_Transmit_Preliminary_Evaluation.pdf

0db/SNR @ 3khz AWGN to include the 75bps Walsh coded in-band Direct Sequence Spread Spectrum (DSSS) modulated waveform in common with MS110A and S4415. It also detects the Appendix B. 39 tone OFDM 44.44 baud symbol rate (at 2 bits per symbol) waveform even further into the noise than serial tone modes and at levels that the MDM-3001 could not decode the waveform. The 2G LBT was subjected to additional military, commercial and amateur waveforms in channel occupancy detection testing under similar parameters. All common and many uncommon waveforms used within the ARS were tested with and detected at weak signal levels. The random station on-the-air testing consisted of making use of all ALE 2-way use of the 2G LBT detector in making ALE Soundings, Linking Calls and Responding to Linking calls. The results of 2-way testing were that the 2G LBT will not and did not permit transmission if there was a man made signal detected. As this detection performance includes signals not heard by the human ear, the 2G LBT performance exceeds my human ability to not interfere with a busy channel. For example, a screen capture of the 2G LBT under test and its ability to detect what would amount to a hidden transmitter while the signal was weak prior to strengthening is depicted in Appendix II attached. SSB Analog Voice detection is a requirement of the MIL-STD due to most use of ALE outside the ARS involves mixed Voice/Data communications on the same frequency. The MIL-STD requires SSB Analog Voice detection at 6db/SNR for 80% probability of detection and at 9db/SNR for a 99% probability. The 2G LBT exceeded these requirement by are large margin. In on-the-air testing signals -120dBm (S2) to -110dBm (S3)[57] were being detected, signals weaker than -110dBm were not present often due to propagation and band activity, also natural noise levels between 2-30Mhz of S4-S6 being normally in occurrence on average but varying considerably. This made finding weak SSB Voice signals to test against a challenge and required both late night, ground wave and being in place at both sunset and sunrise. I am confident that all software modem developers can achieve the same or perhaps better LBT

[57] dBm conversion to µV and S-meter: -109dBm equates to 0.8 µV or S3 for IARU S-meter or 18dB over S0, -115dBm equates to 0.4 µV or S2 for IARU S-meter or 12dB over S0, -121dBm equates to 0.2 µV or S0 for IARU S-meter or 6dB over S0

level of channel occupancy detection performance in their modems as now achieved in our 2G LBT.

31. Regarding the aforementioned practice of Voice/Data. Although outside the specific scope of this proceeding, I feel obligated to comment on the merit of possible consideration by the FCC of authorizing mixed Voice/Data privileges below 29.7Mhz wherever Image emissions are now permitted. The use of mixed Voice/Data has already been proven compatible in ARS use on 60 meters. It is a standard practice in other U.S. radio services, as well as with other countries ARS licensees to include our closest neighbor in Canada. This valuable capability is leveraged in daily use by all U.S. Government and Military stations and personally by this station in MARS and SHARES communications where most stations are also licensed Amateurs. The daily benefit of Voice/Data privileges to the ARS can not be understated, let alone its value in providing support during Emergency Communications. The practice can over come issues with poor channel conditions impeding or completely blocking Phone communications. It speeds up the communication process which means improved spectral efficiency. It provides for greater message accuracy. All important points on a daily basis, however anyone of could mean the difference between life or death in a real emergency situation. The process involved with Voice/Data is little different than the current practice of Voice/Image in that on the same frequency, stations are able to switch between using Voice transmission and Data transmissions on a coordinated basis during the course of the communications. I believe there is enough direct connection with the stated goals in RM-11708 to raise the matter of Voice/Data rule changes at this time due to its overwhelming merit. However I am **NOT** attaching my position on Voice/Data as a condition for the adoption of RM-11708 by the Commission.

32. Future significant contributions to radio science by ARS licensees moving along at the current snails pace can not be ruled out. However the ARS requires an impetus to capture the

imagination of the 21st century digital age youth, budding software and hardware engineering students, possessing better math and DSP skill sets and vision than mine to become the Radio Amateurs of the future and go where no previous Radio Amateur has gone before. ARS waveform developers are only limited by current hardware technology to host their software or firmware, the developers' skills set and the developers' vision and motivation, the later of which is heavily influenced by the current FCC rules.

In closing, I am compelled to state that the U.S. Amateur Radio Service is somewhat stalled as to HF data waveform technology and is in need of a jump start. In addition, an equitable redistribution of frequency assets among the authorized types of emissions is required where there has long existed the situation of too much weight being assigned to Phone when compared to Data emission and CW allocations. The authorization of mixed Voice/Data would address this, just as CW can already be used in this manner. The alternate approach being the adoption of the "any emission anywhere model" used in many other countries with the exception of automatically controlled digital stations involved in message forwarding systems which should have exclusive frequency boundaries regardless of emission bandwidth, but larger than current sub bands.

I sincerely believe that to address the issue of "Symbol Rate Rule Modernization" the adoption of RM-11708 is in the best interests of the U.S. Amateur Radio Service and therefore I recommend it be adopted in a timely manor.

Thank you for the opportunity to comment in support of RM-11708. I have found my first NPRM experience to require a great deal of thought and deliberation and to be a challenge with respect to being succinct, yet clear and concise at the same time in my comments. I very much look forward to the Report & Order. I may be reached at the points of contact listed below for any questions or clarifications regarding my comments herein.

Respectfully submitted this 19th day of December, 2013:

/s/ Stephen B. Hajducek, N2CKH
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Hendersonville, NC 28792
1-828-393-7385
n2ckh.com@gmail.com

APPENDIX I

STANAG 4415 performance requirements are Bit Error Rate (BER) $<10^{-3}$, -9db/SNR @ 3Khz AWGN single path, non-fading channel. For BER $<10^{-4}$, dual path and multipath = 10.0ms the requirements are detailed in table 1 below as to fading and .minimum SNR @ 3Khz AWGN channel.

Doppler Spread (both paths) hz	Required SNR (db) to achieve 10^{-4}BER
0.5	0.0
1.0	-1.0
2.0	-1.0
5.0	-1.0
10.0	-1.0
20.0	-1.0
30.0	-1.0
40.0	-0.5
50.0	0.0

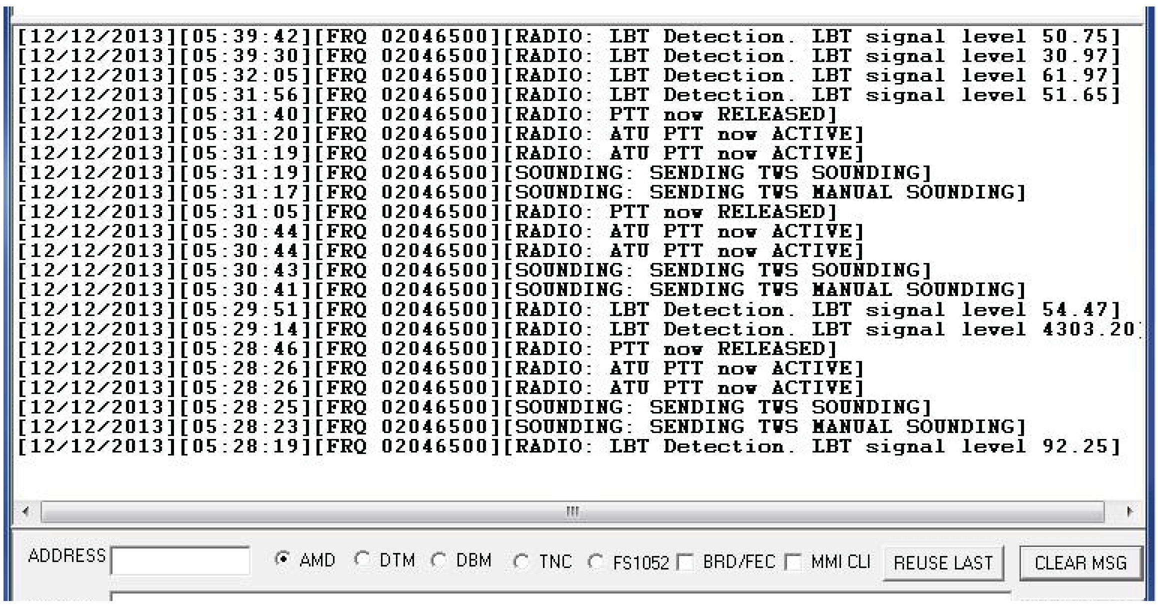
Table 1.

APPENDIX II

The following information was extracted directly from the Test Setup section of “Preliminary Test Results of MARS-ALE Second Generation Listen Before Transmit Detector December 2013”[58] where MARS-ALE v3.00 Build 3.0.0.0 Test Build #2 was the Software Unit Under Test (UUT)

To monitor the incoming signal source spectrum, in addition to the Tones display of MARS-ALE, Spectrum Lab v2.77b02 was used at all times which allowed for a visual display of the spectrum and waterfall where the time stamped display could be captured for correlation to the time stamped LBT detection engineering window message in MARS-ALE.

For example, review the screen capture below that depict LBT detection events when the use of the Manual Sounding feature is being attempted.



In he screen capture note that at 05:39:30 the LBT inhibited TX, the LBT signal level at the time was listed as 30.97, then at 05:39:42 note another LBT event and the LBT signal level at the time was listed as 50.76 where these values are return from the LBT routine as an indication of the magnitude squared of the symbol energy detected and if exceeding the LBT threshold, which in this and all cases herein, was set to the default value of 25, an LBT detection event shall then ensure.

Now review the waterfall in the image below of the in coming signal that the LBT events trigger on and look at the time stamps on the left hand side, you will observe the weak signal which can be thought of as a hidden transmitter signal in the noise floor, all of a sudden become a strong signal just prior to 05:39:40 as the display is calibrated, likely at 05:39:39, the signal from its start was weak and detected by the 2G LBT and then became stronger, a signal that the human ear when weak would likely not detected.

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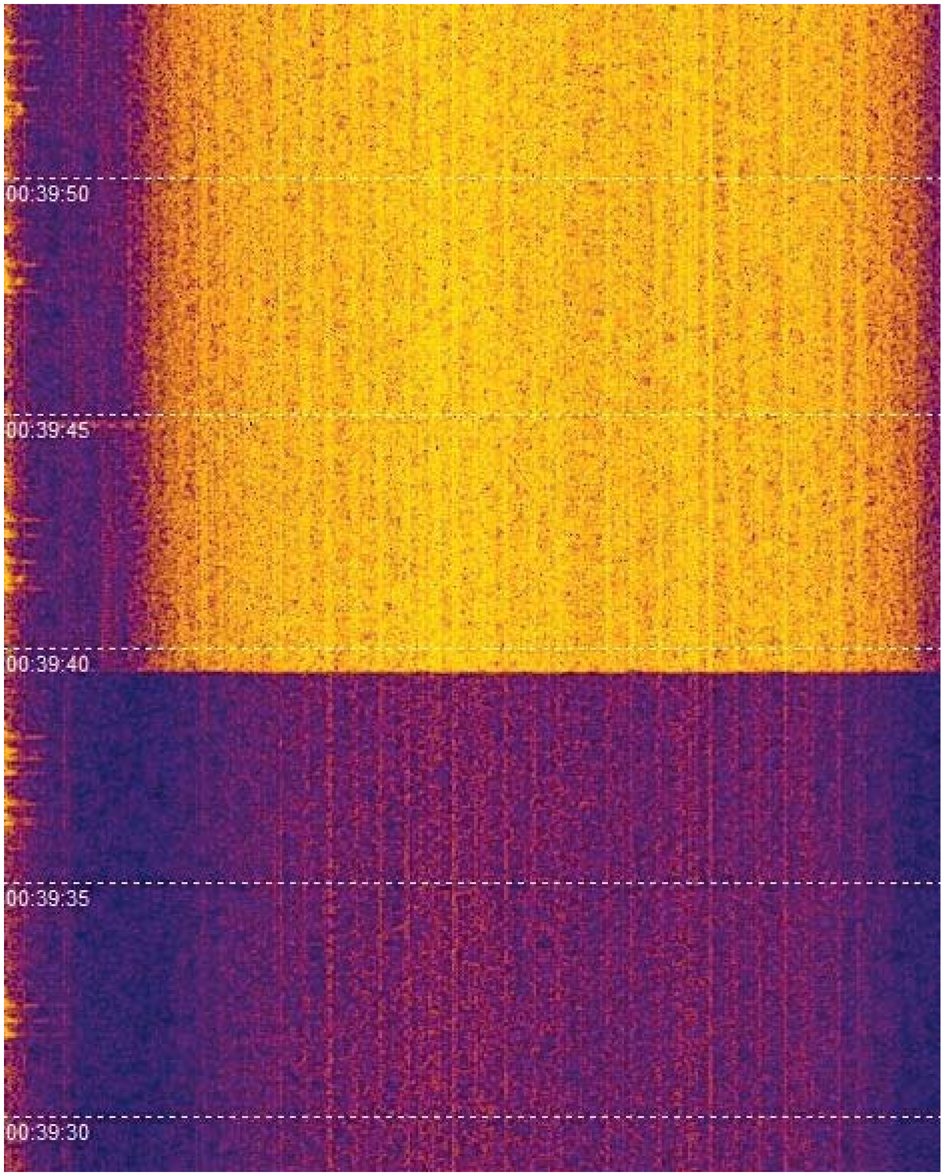
[58]Preliminary Test Results of MARS-ALE Second Generation Listen Before Transmit Detector by N2CKH December 2013 www.n2ckh.com/MARS_ALE_FORUM/MARS-ALE_2G_Listen_Before_Transmit_Preliminary_Evaluation.pdf


00:39:50
00:39:45
00:39:40
00:39:35
00:39:30